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DIET COMPOSITION OF THE LONG-EARED OWL IN CENTRAL SLOVENIA: SEASONAL VARIATION IN PREY USE

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ABSTRACT.—The diet of long-eared owls (*Asio otus*) was examined in central Slovenia during 1989–91. Mammals were the most common prey group (97% by number), with the common vole (*Microtus arvalis*) as the most frequent prey species (46%); its proportion in the diet varied yearly and seasonally (range 11–90%) according to its population density. When this vole's densities were low, owls shifted their predation pressure to alternate prey. Mice from the genus *Apodemus* were the most common alternate prey. Their proportion in the diet increased during winter and during year-round shortages of main prey as well. Other prey species contributed significantly only during winter (*Microtus agrestis* and *Pitymys subterraneus*) or only during year-round shortages (*Arvicola terrestris* and birds). Body size of the three prey species with highest proportions in the pellets (*M. arvalis, M. agrestis,* and *Apodemus sylvaticus*) varied with the season, the largest being during summer and the smallest during winter.

KEY WORDS: Asio otus; *diet composition; long-eared owl; prey size; seasonal variation; Slovenia.*

Composición de la dieta de *Asio otus* en Eslovenia Central: variación estacional en el uso de presas

RESUMEN.—Durante 1989 a 1991 se examinó la dieta de *Asio otus* en Eslovenia Central. Los mamíferos constituyeron el grupo de presas más común (97% por número) y cuya especie-presa más frecuente fue *Microtus arvalis* (46%). La proporción de *M. arvalis* en la dieta varía anual y estacionalmente (rango: 11 a 90%) de acuerdo a su densidad poblacional. Cuando sus densidades fueron bajas, *A. otus* incrementaba la depredación sobre presas alternativas; su proporción en la dieta se incrementaba durante el invierno y en los períodos de baja densidad intra-anual de la presa principal. Otras especies-presa contribuyeron significativamente a la dieta solamente en invierno (*Microtus agrestis, Arvicola terrestris* y aves). El tamaño corporal de tres especies-presa, con altas proporciones en las egagrópilas (*M. arvalis, M. agrestis* y *Apodemus sylvaticus,* variaba con la estación, siendo más grandes en verano y más pequeñas durante el invierno.
[Traducción de Ivan Lazo]

The diet of the long-eared owl (*Asio otus*) has been studied extensively throughout Europe and North America (summarized in Schmidt 1974, Marti 1976, Mikkola 1984, Cramp 1985). Due to difficulties in finding pellets during the breeding season, however, many studies have a bias toward the winter diet. Some authors tried to overcome this by presenting results of pellet analyses separately for winter and summer or breeding and nonbreeding season (Armstrong 1958, Sulkava 1965, Glue and Hammond 1974, Goszczinsky 1981). Only Nilsson (1981) and Wijnandts (1984) evaluated long-eared owl diet year round.

I present data on long-eared owl diet derived from pellets collected throughout the year in central Slovenia. My major goal was to evaluate seasonal differences in prey species composition and prey size.

METHODS AND MATERIALS

Long-eared owl pellets were collected systematically from January 1989 to December 1991 at three localities on Ljubljana moor (south of the city of Ljubljana, Slovenia) The study area (about 160 km^2) was homogenous farmland. In localities where pellets were collected forest patches of predominantly *Pino sylvestris-Betulletum* and *Betulo-Quercetum roboris* types (for a more detailed description see Tome 1991). Sampling at each locality took place at least once a month. Small mammal remains in the pellets were identified to species according to Kryštufek (1985) Birds and insects were not identified beyond class because of their low numbers. Biomass was calculated using average mass of prey species (see Tome 1991).

For study of year-round variation in the diet, prey (by number) were pooled for each year into six 2-mo periods beginning with January. Due to their small proportions and low variability in the diet, species in the genera *Micromys, Rattus,* and *Apodemus* were pooled as "mice," and species in the genera *Sorex, Neomys, Crocidura* as "shrews."

Table 1. Diet composition of the long-eared owl in central Slovenia (*N*% = dietary percent by number, B% = dietary percent by biomass).

	1989	1990	1991	1989–91	
PREY	*N*%	*N*%	*N*%	*N*%	B%
Microtus arvalis	66.6	52.3	21.2	44.2	45.6
Microtus agrestis	13.3	17.8	11.6	14.3	20.2
Pitymys subterraneus	7.1	8.3	10.2	8.7	6.0
Clethrionomys glareolus	2.5	1.2	3.8	2.5	2.4
Arvicola terrestris	tr.[a]	0.4	5.7	2.3	5.0
Apodemus sylvaticus	5.1	7.1	14.4	9.4	7.7
Apodemus flavicollis	tr.	2.1	0.3	0.9	0.8
Apodemus spp.	2.2	5.6	15.5	8.5	6.9
Micromys minutus	0.9	2.9	7.5	4.1	1.2
Rattus norvegicus	tr.	tr.	0.1	tr.	0.1
Sorex araneus	tr.	0.3	2.4	1.0	0.4
Neomys fodiens	tr.	tr.	0.1	tr.	tr.
Crocidura leucodon	0.9	0.3	0.1	0.4	0.2
Crocidura suaveolens	tr.	0.1	0.2	0.1	tr.
Crocidura spp.	0.1	tr.	0.2	0.1	tr.
Muscardinus avellanarius	tr.	0.2	0.4	0.2	0.3
Talpa europaea	tr.	0.1	0.4	0.2	0.8
Total mammals	98.7	98.7	94.1	97.0	97.7
Birds	1.2	1.1	4.8	2.5	2.3
Insects	0.1	0.2	1.1	0.5	tr.
Total number	691	921	999	2611	
Total biomass (g)				60 726	

[a] <0.1%.

Dormice (*Muscardinus avellanarius*), moles (*Talpa europaea*), and insects were grouped together as "other."

Food-niche breadth (FNB) was calculated according to Levins (1968). In these calculations unidentified individuals in the genera *Apodemus* and *Crocidura* were assigned to species in the same proportions as their identified counterparts. Birds and insects were regarded as only two taxons.

An index of the size of prey individuals of the three most frequent prey species in the diet (common vole [*Microtus arvalis*], field vole [*Microtus agrestis*], and wood mouse [*Apodemus sylvaticus*]) was obtained by measuring the distance between the upper incisor and the third molar (IM3) on one side of each unbroken skull. Measurements were taken to the nearest 0.1 mm using a caliper.

To assess relative abundance of dominant prey species in the field, snap traps were set in spring and early summer. Traps were placed 5 m apart in lines of 30 and left for one night. Altogether 1290 trap nights were accumulated on the grasslands in 3 yr. A snap-trap index (STI = number of animals caught per 100 traps) was used to determine density.

RESULTS

Diet Composition. Fifteen species of small mammals were found in pellets of the long-eared owl from Ljubljana moor with the common vole being the most frequent (>40% by number). Among major prey groups, voles (*Microtus, Pitymys, Clethrionomys,* and *Arvicola*) were dominant, constituting 72% of prey items by number, followed by mice (*Apodemus, Micromys, Rattus*; 23%), birds (*Aves*; 3%) and shrews (*Sorex, Neomys, Crocidura*; 2%). The proportion of insects was negligible (<1%). Proportions of prey species by biomass were similar to proportions by number, because of similar average weights of the most frequent prey species (Table 1).

Year-to-year diet of the owls changed considerably ($\chi^2 = 564$, $P < 0.01$). Species most variable in the diet were common voles and mice from the genus *Apodemus,* followed by water voles (*Arvicola terrestris*), harvest mice (*Micromys minutus*), and birds. Proportions of field voles, common pine voles (*Pitymys subterraneus*), and bank voles (*Clethrionomys glareolus*) were more stable (Table 1).

Seasonal Variation in Prey Use. Most prominent in the seasonal variation in prey use were the summer-autumn peaks of the common vole, which

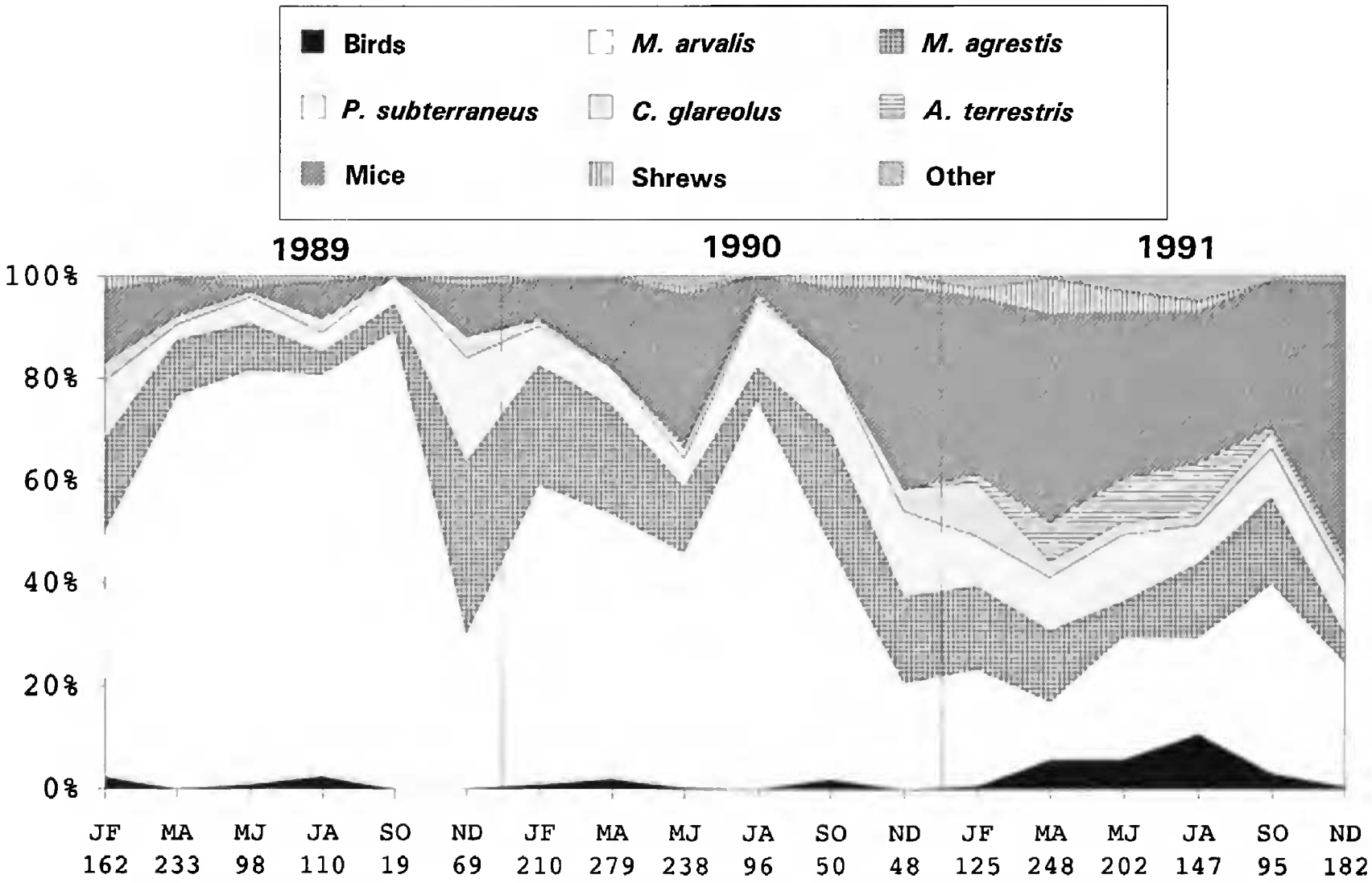

Figure 1. Seasonal variation in the diet (proportions by number) of the long-eared owl during 1989–91 in central Slovenia in 2-mo intervals. Sample size is given below x-axis intervals.

constituted up to 90% of food intake by number in that period. The winter diet shifted notably from common voles to mice, field voles, and common pine voles. In 1991, mice were taken more frequently throughout the year, but field and common pine voles did not surpass the proportions found in pellets in previous years. During the summer of 1991, the proportions of water voles and birds markedly increased (Fig. 1).

The relationships between main and alternate prey in the diet were investigated using correlations between proportions of the species in the diet and the FNB. Optimal foraging theory predicts that FNB should expand when the density of the main prey species decreases and shrink when the main prey increases (Pyke 1984). This means that the most important main prey species have the largest negative correlation coefficient and the most important alternate prey have the highest positive correlation.

FNB was usually low during the summer and high during the winter, but in 1991 it was high throughout the year (Fig. 2). Correlation between the proportion of species in the diet and the FNB revealed that the common vole was the only main prey for long-eared owls. Wood mice were the most important alternate prey, followed by water voles and shrews (Table 2).

Population Density of Common Voles. Density of common voles, the main prey species and the most

Table 2. Spearman rank correlations between proportions of species found in pellets of long-eared owls and the food-niche breadth of the owls' diet.

SPECIES	r_s
Microtus arvalis	−0.97[a]
Microtus agrestis	0.21
Pitymys subterraneus	0.48
Clethrionomys glareolus	0.52
Arvicola terrestris	0.68[a]
Apodemus spp.	0.84[a]
Micromys minutus	0.56
Soricidae	0.66[a]
Birds	0.56

[a] $P < 0.01$.

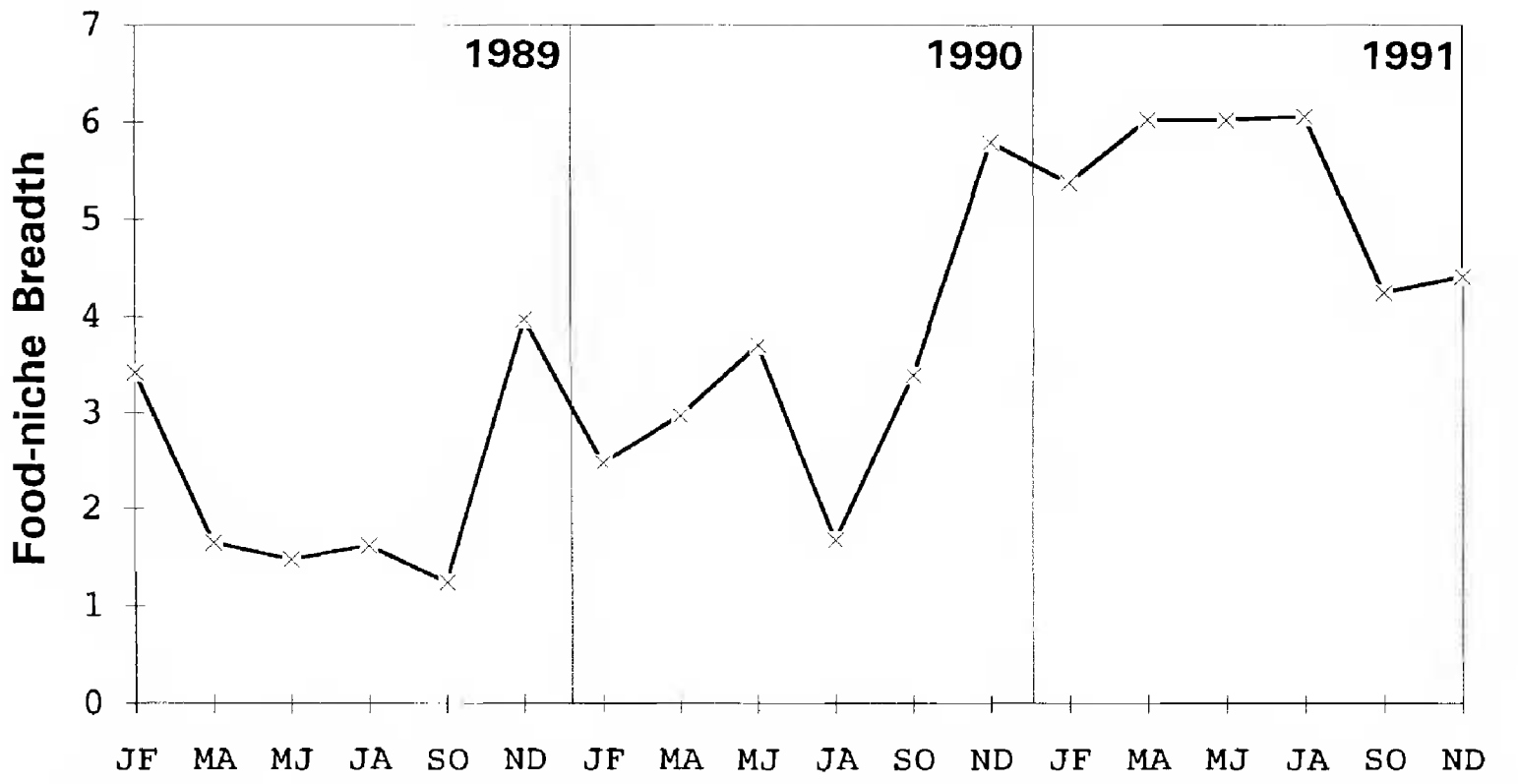

Figure 2. Seasonal variation in the food-niche breadth (FNB) in the long-eared owl in central Slovenia in 2-mo intervals.

variable one in the long-eared owls' diet, varied widely in the field. It was highest in 1989 (STI = 21.03), intermediate in 1990 (STI = 11.71), and the lowest in 1991 (STI = 0.26).

Seasonal Variation in Prey Size. Body size as estimated by the average IM3 distance varied significantly between 2-mo periods in the three most common prey species (ANOVA; common vole, $F = 9.50$, $P < 0.01$; field vole, $F = 6.84$, $P < 0.01$; and wood mouse, $F = 5.95$, $P < 0.01$). This measurement was greater during the summer than during the winter, being shortest in the last third of the year (September to December; Fig. 3).

DISCUSSION

Diet of the long-eared owl in this study was similar to diets elsewhere in Europe (summarized in Schmidt 1974, Marti 1976, Mikkola 1984, Cramp 1985). Small mammals contributed a majority of prey items by number (97%) and by mass (98%). The rest were birds (2%) and insects (1%). FNB index was, in contrast to Sweden (Nilsson 1981) and the Netherlands (Wijnandts 1984), higher during winter than during the summer.

In years of its abundance, the common vole was by far the most important species in the summer and autumn diet. During the winter and spring, as well as during the summer and autumn in 1991 when densities of the common vole were low, proportions of alternate prey in the diet increased notably. Mice were the most important alternate prey because their proportion increased during winter as well as during year-round shortages of common voles. Other species contributed significantly only during winter (field vole and common pine vole) or only during year-round shortages of common voles (water vole and birds) clearly diminishing their importance as alternate prey.

In Sweden, dense vegetation in summer presumably reduced the availability of voles in relation to other prey which resulted in increased proportions of alternate prey and also increased FNB in the long-eared owl (Nilsson 1981). Open habitats on Ljubljana moor (main hunting habitat of long-eared owls; Tome 1991) regularly had low vegetative cover during winter. Snow cover during this study was practically nonexistent. Consequently heavy vegetative or snow cover could not have been the reason for increased FNB on Ljubljana moor during winter.

It is well-known that populations of small mammals are lowest during winter (Petrusewicz 1983, Tamarin 1985). On the other hand, the proportion of the common vole in the diet of the long-eared owl is dependent on the abundance of this species in the owls' hunting habitat (Korpimäki 1992). I suggest that low density of common voles in open habitats during winter, as well as during most of 1991, was the main reason for decreased proportion of this

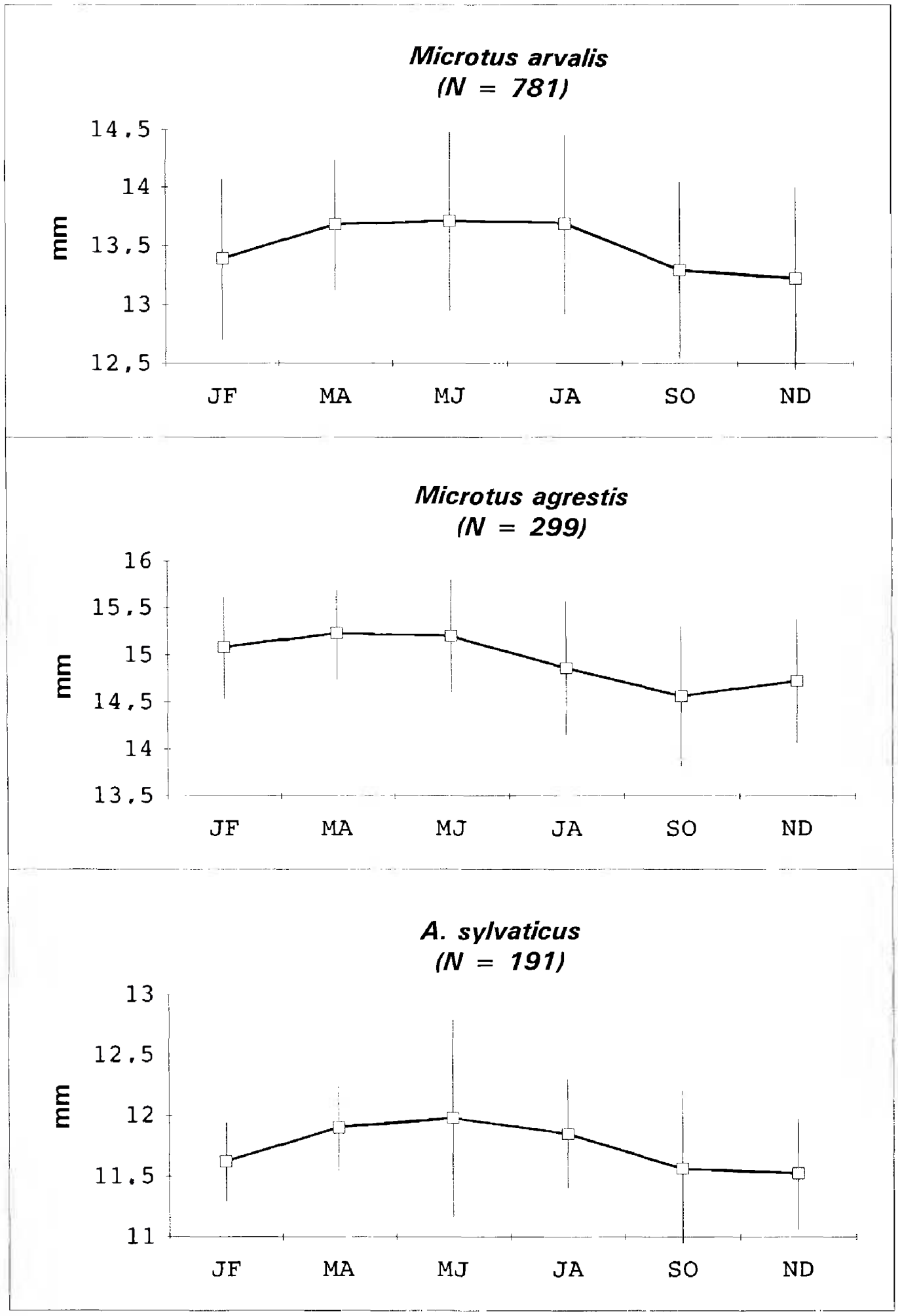

Figure 3. Average distance between the upper incisor and the third upper molar in small mammals found in pellets of long-eared owls during 1989–91. Results are pooled according to date of origin into 2-mo periods. Vertical lines show standard deviation.

species in the diet and in consequence for increased FNB. How the variable body sizes of prey species influences the diet of the long-eared owl is still to be evaluated.

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